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Teachers' voice use in teaching environment. Aspects on speakers' comfort

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Abstract

Teachers have high occupational voice demands. The voice load of teachers is both environmental and individual. Little is known about the teachers' own view of the contribution from the environment and about the teachers' voice use at their work-place. *Aim*: The purpose was to investigate the voice use and prevalence of voice problems in teachers and to explore their ratings of vocally loading aspects of their working environment. *Method*: A questionnaire-survey in 467 teachers aiming to explore the prevalence of voice problems in teaching staff identified teachers with voice problems and vocally healthy colleagues separated in two groups, teachers with self-assessed voice problems and vocally healthy teachers. Teachers with voice problems were further, matched to a voice healthy colleague from the same school. The pairs were investigated and compared for clinical findings and for vocal behavior in the teaching environment and aspects of the classroom environment were also measured. *Results:* Teachers with voice problems were more affected by any loading factor in the work-environment and were more perceptive of the room acoustics. Differences between the groups were found during field-measurements of the voice, while there were no differences in the findings from the clinical examinations of larynx and voice. *Conclusion*: Teachers suffering from voice problems react stronger to loading factors in the teaching environment. It is in the interplay between the individual and the work environment that voice problems emerge.

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Keywords: occupational voice, classrooms; teachers; room acoustics; subjective assessment; speakers' comfort

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1. Introduction

During the last decades, there has been an increasing media focus on the non-optimal sound environment in schools. However the focus has mainly been on the listeners and the sound environment in general, not so much on teachers' voice use and the consequences of vocal problems. Nevertheless, research in the area of occupational voice problems and Voice Ergonomics has gained increasingly more interest and especially in teachers [1]. In 1996, Fritzell presented a paper on voice and occupations, identifying teachers to be the most common occupational group at voice clinics, the percentage of which largely exceeded the total percentage of teachers in the population at that time in Sweden [2]. The prevalence of voice problems in Swedish teachers is, however, largely a substantial number of unrecorded cases. Voice difficulties at work seem to be regarded as more of an individual problem, depending on the individual's innate capacities or voice use or "abuse", than as an occupational hazard [3]. Vilkman (2000) summarizing relevant studies that have investigated subjective complaints among teachers, concluded that the majority of teachers have experienced vocal problems and 5% suffer from problems so severe that their working ability is questionable [3]. Verdolini & Ramig, (2001) estimated the costs for sick-days and treatment in US teachers to $2.5 billion [4]. Teachers have reported that their work performance is affected by their voice capacity and vocal problems [e. g. 5, 6] and there are findings indicating that the students' understanding is negatively influenced by the teacher's hoarse (dysphonic) voice [7-9]. However, although much today is known about teachers' voices and voice use, only a few studies have taken into account the teachers' opinion of their work-environment. Even fewer have explored the teachers' actions in the work environment. Moreover, the work environment, *i.e*. the classroom's air-quality and acoustics, has often been discussed and acknowledged to contribute to the vocal load, but these factors are seldom investigated where and when the teacher is teaching.

The present paper is a summary of the project 'Speakers' comfort and voice disorders in classrooms' [10]. The project aimed at investigating teachers' voice use in relation to the class-room acoustics, based on the hypothesis that the environment influences the way speakers regulate their voices. This is a perspective that has only been scarcely investigated in relation to teachers' voice health. The main purpose of the project was thus, to investigate the voices and the voice use of teaching staff in their teaching environment and to explore the prevalence of voice problems in Swedish teachers. ***Study I*** aimed to explore the prevalence of voice problems in teaching staff and to investigate their ratings of their voice and teaching environment [11]. The follow-up ***Study II***, aimed at investigating the etiology of voice problems in teachers by exploring possible differences between 31 teachers with voice problems and 31 age and gender matched voice healthy colleagues from the same schools [12]. All were recruited among the population of teachers from study I [11]. ***Study III*** was a field study, including 14 of the 31 pairs from *Study II*. The study aimed at closer investigating the vocal behaviour and voice use in teachers with self-estimated voice problems and their age-, gender and school matched colleagues without voice problems, using matched pairs [13]. The main hypothesis of the project was that teachers with and without voice problems act differently with respect to classroom acoustics and air-quality, and that the vocal doses obtained with a voice accumulator would separate the groups. The details on the room acoustics and the measurement of the voice support are described in a counter-part thesis by David Pelegrín-García [14]. For a detailed overview of the projects, see the final project report [10].

2. Method

For ***Study I*** a questionnaire was developed to assess teachers' ratings of their working environment and also to estimate the prevalence of voice problems in teachers. The questionnaire covered fifty-two items in three main domains: 1) background information; 2) room acoustics, perception of noise sources and other issues related to the environment and 3) voice problems, vocal behaviour and statements about skills in voice use. Two statements were considered to be index-statements: #1:" The classroom acoustics help me talk comfortably" and #32:"I have voice problems". The questionnaire was tested for validity in 63 teachers. The questionnaire was distributed to n=487 responders at their collegial meetings at 22 randomly selected schools in the south of Sweden. It was completed anonymously and by 73% of all the teachers at the included schools. After exclusion due to incomplete questionnaires, data from a total of 467 responders (336F:131 M, median age 47, range: 23-69) was finally evaluated. Teaching staff at all levels were included, except pre-school teachers at pre-schools and day-care-centres and teachers at specialised, vocational high schools, due to the large variety of teaching premises. Based on the ratings of statement 32 "I have

voice problems", the participants were divided into two groups. *Group I*, (N=60) consisted of teachers suffering from voice problems (VP) sometimes, often, or always. *Group II* (N=407) included teachers having rated never or only occasionally experiencing voice problems (Voice Healthy, VH). There were no significant differences between the groups for gender (*Group I* 80% F/20% M, *Group II* 71% F/29% M), age (*Group I* Md=49,5, *Group II* Md=46), smoking (*Group I* 10%, *Group II* 7%), or years of occupation (*Group I* Md=20, *Group II* Md=16) as shown by a chi2 test [11].

For ***Study II*** two paired groups of teachers were formed: *Group I* (N=31, 26F/5M) included VP teachers. Median age 51 years (range 24-65) and a median time in occupation of 15 years (range 1-40); *Group II* (N=31, 26F/5M) included VH teachers. Median age of 43 years (range 28-61) and median time in occupation of 14 years (range 2-39). The pairs came from 12 of the 22 schools in study I [11]. The teachers underwent examination of the larynx and vocal folds with a 70 degree rigid laryngoscope. A digital documentation system was used, HRES Endocam (Wolf, Germany). The teachers were recorded both in high resolution mode and high-speed mode (2000 frames/s for male and 4000 frames/s for female subjects). These recordings were used to evaluate mode and symmetry of vibration at the glottal level. A recording of a read text was used for perceptual evaluation of the voice and for acoustic measurements. In addition, a standard Voice Range Profile was used to examine the range of intensities and frequencies that a participant could produce. The subjects also completed a battery of self-assessments, for psychosocial aspects; psychological health; personality; complementary questions on voice and teaching [12].

Study III. The field study examined how classroom acoustics interacts with the voices of 14 teachers without voice problems and 14 teachers with voice problems, all recruited from Study II were also the assessment of the voice problems were made [12]. The pairs formed two equal groups: *Group I*: teachers with self-assessed VP (n=14, 12F:2M median age: 41, range: 24-62, md years in occupation=13, range 2-40), and *Group II*: VH teachers (n=14, 12F:2M median age: 43, range: 28-57, md years in occupation=18, range 2-28). The teachers kept a structured logbook during the workday and were registered with the Ambulatory Phonation Monitor 3200 vers. 1.04 (APM). The APM uses an accelerometer to calculate the movements of the vocal folds, through measurements of the skin vibrations of the neck that occurs during phonation. Based on the vibrations, the phonation duration (% of total registered time), fundamental frequency (in Hz), sound pressure level (in dB), and vocal doses are calculated. The APM does not record ambient noise, nor the spoken message. During teaching, the noise and voice levels at the teacher's position were measured with a sound level meter Svantek, mod. SV-102. The signals were picked up by a lapel microphone at a distance of 15 cm from the teacher's mouth. The teacher's voice level and the activity noise level were separated using mixed Gaussians. In addition, objective acoustic parameters of *Reverberation Time* and *Voice Support*, *background noise level*, *speech transmission index*, *sound strength* and *voice support* [15] were measured in the 30 empty classrooms of the study. A head and torso simulator (HATS) were used for the *voice support* measurements, and an omnidirectional loudspeaker where used for the other room acoustic parameters [16]. Additionally, the geometrical dimensions of the room were measured. The air humidity, room temperature, and the carbon dioxide (CO2) contents of the air were simultaneously measured during the work-hours with an indoor air quality measuring device [13].

3. Results

3.1. Prevalence of voice problems and ratings of environment(Study I)

Based on the index question 'I have problems with my voice' the point prevalence of voice problems in Swedish teaching staff was estimated to 13%. There was a significant difference between the groups VP and VH for the index statement 'the classroom acoustics help me talking comfortably', Mann-Whitney U-test: (z=-3,319) p=0,001. Within the whole group, 38% disagreed that the class room acoustics helps the teacher to talk comfortably. There were significant differences between the groups for several of the items, (Mann-Whitney U-test). The VP teachers rated items on room acoustics and work environment higher, thus as being more noticeable. Within the total group, 92% of the teachers agreed on the presence of noticeable noise from the pupils. Also, the perception of disturbance from other noise sources, such as ventilation noise, noise from technical equipment, and noise from outside the classroom received a moderate to strong agreement by the entire group, but with no statistical differences between the two groups. Fig. 1 and 2 show ratings in the whole group of some of the main items.

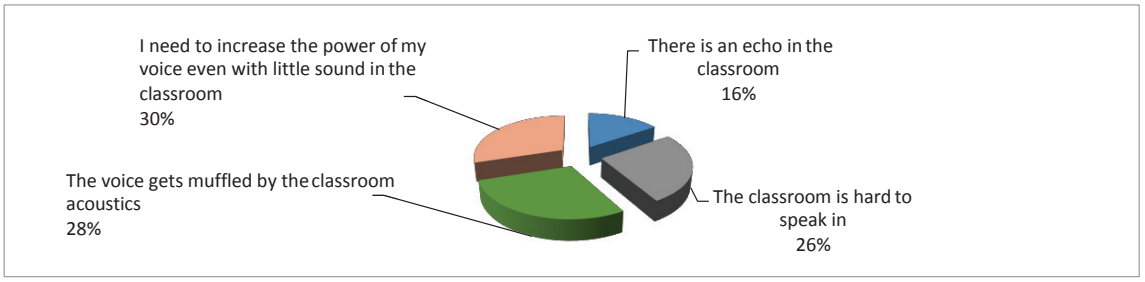

Figure 1. Perception of voice use in relation to the classroom acoustics in % of the total n=476 teachers

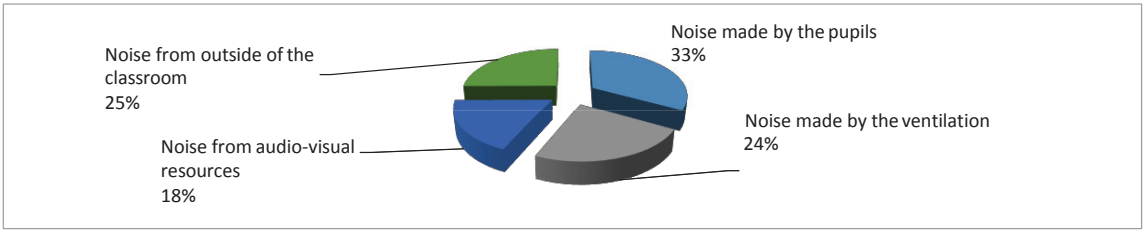

Figure 2. Perceived main sources of background noise in % of the total ratings by n=476 teachers

Moreover, the differences between the groups were significant for all statements within the voice section. Absence from work because of voice problems was significantly more common in the group with voice problems: 35% versus 9% in the group without problems, χ^2 ($p<0,05$).

3.2. Etiology of voice problems (Study II)

The study aimed to explore possible vocal, structural and psychological differences within pairs of teachers. Only scarce differences were found between the groups. Minor morphological abnormalities of the vocal folds were found in 13 subjects (5/31 in the VP Group 8/31 in the VH Group); some remarks on voice quality and hearing were made, and also some negative reports of psychosocial wellbeing but no findings reached statistical significance. Nor did the instrumental analyses of voice range and F0 in running speech reveal any differences. The groups did differ for all questions of voice as shown by paired samples t-test and for time for recovery after voice problems: $\chi 2$, (7 n=60) =17.608, p=0,014. Within the group of teachers with VP, 18% had considered change of work due to voice problems but none in the VH group, as shown by Fisher's exact test (p=0,029).

3.1. Field study of voice use in relation to the work environment (Study III)

The teachers' voice use in the classrooms differed between the groups for a number of parameters. Teachers in the VP group behaved vocally different from their VH peers, in particular during teaching sessions. The *time dose* (% of voicing) was significantly higher in the VP group, throughout the workday, as shown by a paired t-test (p=0.006) and specifically for teaching (p=0.003). The phonation time for teachers in this material varied between 17-24% with the VP group reaching the higher percentage. Also the F0 pattern, related to both voice-SPL and the room acoustics differed between the groups. The VP did not raise their F0 with increasing the voice SPL, whereas the VH group raised the F0 with the SPL increase. The VP group either kept the F0 stable or decreased it. Further, there was a difference between the groups in the subjective assessments of vocal aspects during the day. The VP group with voice problems rated their voice problems during the day significantly worse than their colleagues: paired t-test (p=0.003). The VP group also rated their degree of vocal fatigue (p=0,007) and loss of air during speech (p=0,007) significantly higher than the VH group. An empirical model shows that the measured voice levels (see Fig. 3) depend on the activity noise levels and the *Support* [15,17]. Teachers with and without voice problems were differently affected by the *Support* of the classroom. There were no significant differences between the teaching environments for the VP and VH groups for any of the parameters, STv, STI, or RT, shown by independent samples t tests: STv: $t(23) = -0.86$, $P = 0.399$;

STI: $t(23) = 0.21$, $P = 0.834$; RT: $t(23) = -1.36$, $P = 0.187$. Nor were there any differences between the rooms with regard to ambient air quality, temperature and humidity.

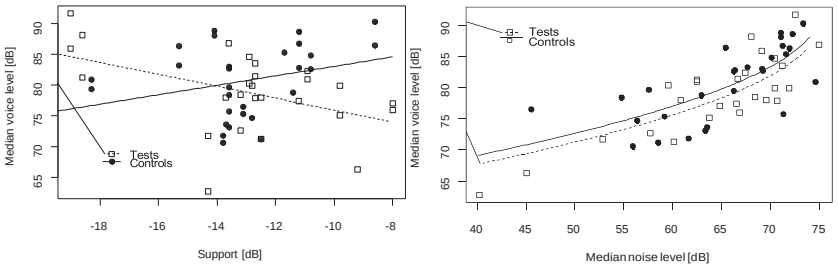

Figure 3. Comparison of the model and the measured values. Left: Median voice level vs Support. Right: Median voice level vs. Median noise level.

4. Discussion

This project corroborates the hypothesis that teachers often suffer from voice problems due to work-related factors. The point prevalence of voice problems in Swedish teaching staff was estimated to 13% which is in line with earlier research from a range of countries. The results indicate that teachers suffering from voice problems react stronger to vocally loading factors in the teaching environment, report more frequent symptoms of vocal discomfort and, are more often absent from work due to voice problems compared to their voice-healthy colleagues. The environmental factors assessed as negatively affecting the vocal load are related to the voice use, background noise, room acoustics, air quality, stress and psychological factors and in the lack of time for rest and recovery. These results align with recent studies, investigating environmental risk factors for voice use [17]. Although a number of room parameters were assessed as influencing the voice use we did not find any measurable differences between the rooms of the groups for temperature, ambient air quality or over-all room acoustics. This might be seen as contra intuitive thus, it is important to underline the complexity of voice and voice problems and the intertwined co-play between individual and external factors. At a group level, the teachers' voice problems emerged most clearly in the interaction with the environment, no significant differences were found between the groups for structural, vocal or psychological factors. Hence, an intriguing finding is the result of the groups' different use of the room acoustic. Teachers with voice problems seem to be more aware of classroom acoustic conditions than their healthy colleagues, as shown in Fig. 3. They seem to make use of the more supportive rooms to lower their voice levels and thus, decrease their *vocal effort* to increase the *vocal comfort (*defined as the speaker's perception of being heard in a room, with little or no vocal effort [18]) and they also prefer longer decay times [19]. Some more factors are importance to consider when describing the speaker's vocal behavior in a room. The distance between the talker and the listener must be tapped as well as the room's prerequisites influencing the auditory feedback of the room and the subjects hearing. There are some limitations to the studies to consider when interpreting the results. We don't know if the long time measurements of voice affected the behavior of the teachers or, that of the students making them less noisy. Further, parts of the findings of vocal effort in relation to the room were made in laboratory research which may have impacted the results through lack of reality. Still, even with cautious interpretation we conclude that speakers with voice problems act differently with respect to the room acoustics and that they would benefit from being trained in using the room to support their voice. Traditionally, research and interventions concerning classroom acoustics have been directed to the listener's perspective and the speech intelligibility of the room and have not taken the speaker's voice use and vocal comfort into account. Based on the findings of the project 'speakers' comfort' [10], Pelegrín-García and colleagues, recently presented guidelines for classroom acoustics design that meet simultaneously criteria of vocal comfort and speech intelligibility [20]. To conclude: Teachers heavily depend on their voice use and voice problems are common. Awareness of the influence of the acoustic properties of the classroom is of great importance when designing teaching environments and in voice care for teachers. Field voice measurements should be included when exploring occupational voice problems since it stands clear that it is in the interplay between the individual and the work environment that the voice problems emerge.

5. Acknowledgments

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